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Weather modification for off-season production of coriander (*Coriandrum sativum* L.) for leaf

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ABSTRACT

Coriander is produced almost throughout the year for leaf purpose, however the demand for leaf during summer is high. The present investigation is under taken to study the weather modifications and their influence on production of coriander for leaf purpose during summer. Nine different production systems and their effect on micro-climate were studied. The study indicated that among the various weather factors studied, soil temperatures significantly influenced the germination, crop growth and yield. Soil temperature was significantly negatively correlated with number of leaves, leaf length, green biomass, shoot weight, leaf weight and yield. The mean afternoon (both ambient and soil) temperatures were also significantly negatively correlated with above growth parameters. The overall results of the experiment suggest that the soil temperatures are the most crucial factor in summer production of coriander. The afternoon soil temperature if ameliorated and maintained between 28. 0^{o} C to 32.5^{o} C, coriander production can be taken up successfully without any modification of other weather factors like air temperature and relative humidity. However, amelioration in ambient air temperature further improves the efficiency of the production system.

Key words: Coriander, off-season production, temperature and relative humidity.

Coriander is known for both green and seed spice because of its unique aroma. Coriander leaves are rich in minerals and vitamins, with typical aroma, hence they are used widely as greens in many delicacies. Coriander is produced almost throughout the year for leaf purpose in India. However, the cultivation for leaf purpose is restricted to July to February months of year. There is a great demand for leaf during summer months from March to June; as production is limited to only a few areas of the country where summer temperatures are low. Isbell (2009) also reported that coriander can be grown under a short season production and has potential to rotate as a second crop following winter crop and can get remunerative income in a short span of time. Waiganjo *et al.,* (2007) suggested that intercropping with coriander improve the quality of the snap bean by reducing thrips incidence and pod damage. However, high temperature is considered as major limiting factor for the germination and growth of coriander during the summer. Bomme *et al*., (2007) studied the spring cultivation of coriander for leaf and suggested that the coriander variety 'Santos' for the highest leaf yield. Temperature plays an important role during the vegetative growth and grain formation of wheat (Marcillous and Single, 1972). John (1957) in his study on Corn, established that soil temperatures play crucial role in germination, growth and yield of corn. Hundal (2004) observed that a 2.0 ^{o}C increase in temperature resulted in 15 to 17% decrease in grain yield in rice under the low temperature conditions. Germination and establishment of the crop are severely affected during summer. However, among the various weather factors, the influence of specific factor on germination, crop establishment and growth is not known. In view of the great demand for leaf in summer months and paucity of information on weather modification on summer production of coriander, the present investigation is under taken to study the effect of weather modifications and their influence on production of coriander for leaf purpose during summer.

MATERIALS AND METHODS

The present study was conducted during the summer season of 2007-08 at RARS, Lam, Guntur District, Andhra Pradesh with an objective to study the influence of modified weather production systems on germination, crop growth, and yield of the coriander. The coriander variety Sadhana was used for the present study. The crop was sown during the second fortnight of May 2007. As the purpose of the present investigation was on yield of leafy coriander, harvesting was done at 40days after sowing.

Nine different production systems (i) gunny housed trench, (ii) gunny housing, (iii) gunny housed raised bed, (iv) gunny housed - brick lined bed, (v) Palmyra leaf thatched housing, (vi) 75% shade net, (vii) 75% shade house with cement floor, (viii) tree shade and (ix) control (open), were studied for variation in their micro-climate in terms of soil

Table 1: Summary statistics of the variables studied in different production systems

Variable	Minimum	Maximum	Range	Mean	Std. deviation
Afternoon air temperature (°C)	39.5	42.2	2.7	40.3	0.8
Afternoon Relative humidity (%)	40.1	56.9	16.8	50.0	5.1
Afternoon Soil Temperature (°C)	28.1	38.1	10.0	32.3	3.2
Number of leaves per plant	3.8	7.4	3.6	6.3	1.3
Leaf length (cm)	4.8	19.4	14.6	11.8	5.0
Biomass (per 10 plants)	6.5	27.8	21.3	19.7	7.8
Shoot length (cm)	3.8	14.0	10.2	10.1	3.8
Mean leaf weight (mg)	2.8	15.2	12.4	9.6	4.3
Yield (t ha^{-1})	1.0	9.0	8.0	4.3	3.2

temperature, air temperature and relative humidity.

The gunny housed trench is a trench with 15 cm depth, covered with gunny housing at a height of 30 cm from the ground (45 cm from soil) so that higher relative humidity can be maintained in the housing. Drainage is provided through a channel to remove any excess water in the trench. The gunny housings used in the experiment are intended to provide much desired shade with a provision of modifying the relative humidity and temperature inside with periodical sprinkling of water on the gunny surface and linings wherever they are used. The gunny housed raised bed is 15 cm height raised bed covered with gunny housing at a height of 60 cm above the ground thus improving the humidity inside. The gunny housed - brick lined bed is a raised bed with 15 cm height which is lined with bricks along the perimeter of the plot so that higher humidity is maintained in the chamber. Palmyra leaf thatched housing is a normal leveled ground on which palmyra thatched roof is arranged at a height of 60 cm with four sides kept open. This structure was designed to provide shade only and permitting free flow of air. 75% shade net treatment is housing all the four sides and roof with 75% shade net. The roof is arranged at a height of 60 cm from the ground. The shade house is a permanent structure (chilli poly house solar dryer) used for growing of coriander in trays. Both these treatments are included as they provide shade alone and are freely permeable to surrounding environment. Wetting of gunny housing and thatched house was done with hose pipe thrice a day viz. 8.00 a.m., 12.00 noon and 4.00 pm. Each system except the shade house, were laid with one meter height with uniform plot size of 16 m^2.

The air temperature and relative humidity above the crop canopy (at 30 cm height) were recorded with a hand held device. Soil temperatures are recorded at 5 cm, 10 cm and 15 cm depth using soil thermometers. The data on plant characters like number of leaves, leaf length, green biomass, shoot weight, leaf weight and yield were recorded at 35-40 days after sowing (foe leaf purpose). Uniform sample size of ten plants was taken for growth characters where as yield was recorded in a 16 m^2 plot. Plant samples were collected at 35 days after sowing. The data on micro-climate and plant growth are correlated using the data obtained from the production systems. Collinearity and regression were worked out to know the relative importance of studied weather parameters and their utility in predicting the yield during off-season.

RESULTS AND DISCUSSION

The mean data of weather and growth parameters in all the production systems are given in Table 1. Among the weather factors studied, dispersal of air temperatures around the mean was lowest followed by soil temperatures and relative humidity as indicated by the standard deviation of 0.8, 3.2 and 5.1 respectively (Table 1). This indicated that the different production systems had less effect on modifying the air temperatures (range of 2.7) while they had more pronounce influence on soil temperature (range of 10) and relative humidity (16.8) which may be due to frequent irrigation to the beds that created change of microclimate in different beds resulting in lowering soil temperatures and enhancement of humidity resulting in wider variation in these parameters.

Among the plant growth characters, maximum deviation was observed in biomass (7.8) and least was observed in number of leaves per plant (1.3). The standard deviation for yield was abnormally high (3.2 t ha^{-1}) indicating the yield spread (range of 8.0 t ha^{-1} with the mean of 4.3t ha^{-1}) among the test production systems was very wide, thus each production system exhibited considerable influence on yield.

Correlations among the weather factors and plant growth characters and yield indicated that there were strong correlations among these variables (Table 2). Further, among the weather factors studied, soil temperatures significantly influenced the germination, crop growth and yield. Afternoon

Table 2: Correlations among the weather parameters, crop growth and yield in Coriander in summer

	Afternoon air temperatures (°C)	Afternoon RH %	Afternoon Soil Temperatures (°C)	No. of leaves per plant	Leaf length (cm)	Green biomass (g 10^{-1} plants)	Shoot weight (g 10^{-1} plants)	Leaf weight (g 10^{-1} plants)	Yield ($t ha^{-1}$)
Afternoon air temperature (°C)	1	-0.373	0.808(**)	-0.901(**)	-0.753(*)	-0.810(**)	-0.808(**)	-0.774(*)	-0.458
Afternoon RH %		1	-0.419	0.515	0.471	0.583	0.58	0.563	0.595
Afternoon Soil Temperature (°C)			1	-0.871(**)	-0.872(**)	-0.807(**)	-0.887(**)	-0.701(*)	-0.752(*)
No. of leaves per plant				1	0.830(**)	0.974(**)	0.968(**)	0.937(**)	0.603
Leaf length (cm)					1	.785(*)	.894(**)	0.656	0.823(**)
Green biomass (gm 10^{-1} plants)						1	0.974(**)	0.980(**)	0.562
Shoot weight (gm 10^{-1} plants)							1	0.909(**)	0.712(*)
Leaf weight (gm10^{-1} plants)								1	0.406
Yield ($t ha^{-1}$)									1

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

soil temperatures has significantly and negatively correlated with number of leaves (r= -0.871**), leaf length (r= -0.872**), green biomass (r= -0.807**), shoot weight (r= -0.887**) and leaf weight (r= -0.7*). As expected, afternoon soil temperature was significantly positively correlated with afternoon air temperature (0.808**). The afternoon air temperature was also significantly negatively correlated with number of leaves (r= -0.901**), leaf length (r= -0.753**), green biomass (r= -0.810**), shoot weight (r= -0.808**) and leaf weight (r= -0.774*). This indicates that both air and soil temperatures had significant role in the production of summer production of coriander. Regarding yield, afternoon soil temperatures was significantly and negatively correlated with yield (r= -0.752*), revealing that the soil temperature played crucial role in summer production of coriander. In the present study in different modified treatments soil temperatures were maintained between 28.0-32.0 °C due to wetting which ultimately resulted in better growth and yield of coriander. Where as there was no change in air temperatures due to wetting and these higher temperatures resulted in low yields which is indicated by the correlation studies. However, there was no significant correlation between yield and afternoon air temperature. This indicates any climate modification systems should consider the management of soil temperatures rather than air temperatures (ambient) in the coriander crop microclimate. In the present investigation also frequent irrigation resulted in creation of micro climate and it has more impact on soil temperatures rather than air temperatures and resulted in germination and better growth of the coriander crop in different production systems, where as in control the growth of leafy coriander is effected due to high soil temperatures resulting in poor leaf growth and low yields.

The study also revealed that there were specific relations among the weather parameters and plant growth and yield. The number of leaves, leaf length, leaf weight and biomass showed a linear (inverse) relationship to afternoon air temperature between 40.2 °C and 42.5 °C and non-linear relationship between 39.0 and 40.2 °C indicating that once the temperatures reached tolerable limits for the crop, other factors play crucial role in promoting the emergence and growth of leaves. Number of days to germination also found to have linear relationship with afternoon air temperature between 40.2 °C and 42.5 °C and non-linear relationship between 39.0 and 40.2 °C. Yield has inverse relationship with afternoon soil temperature. However, relative humidity within the range of 40% to 58% range showed non-linear relationship with crop growth and yield indicating that when other weather factors are within the tolerable limits, indicating that relative humidity of the observation period was not a constraint to production. The observations on mean afternoon

Table 3: Mean yield and afternoon air and soil temperature under different production system.

S.No.	System of Production	Mean afternoon air temperature (°C)	Mean afternoon soil temperature (°C)	Yield (t ha⁻¹)
1	Gunny Housed Trench	40.0	31.8	1.0
2	Gunny Housing	40.2	32.1	3.7
3	Gunny Housed Raised bed	39.9	32.5	1.5
4	Gunny Housed - Brick lined bed	39.7	32.2	4.6
5	Palmyra Thatched Housing	39.5	29.4	8.2
6	Tree Shade	40.3	28.1	7.5
7	Shade net	40.0	30.0	9.0
8	Shade House with cement floor	42.2	38.1	1.4
9	Control	41.0	36.1	1.8

soil temperature indicated that there is a linear (inverse) relationship between mean afternoon soil temperature and number of leaves, leaf length, shoots length, leaf weight, biomass and yield within the range of 32.5 °C to 38.5 ° C. However, a non-linear relationship is observed within the 28 °C to 32.5 °C. Thus the data revealed that for proper growth and yield of green coriander during summer, the soil temperatures should be maintained at or below the 32.5 °C. The different weather modification systems for summer production should include the components that keep the soil temperatures below or at 32.5 °C. The non-linear relationship at these optimum levels of soil temperatures (28 °C to 32.5 °C), further suggests that crop management practices may play important role in plant growth and yield when optimum soil temperatures are provided.

The regression equation generated using mean ofternoon air temperature (a) and soil temperature (s) was $y= -27.0 + 1.665\ a - 1.111\ s$, which can be used to predict the yield (Table 3).

The overall results of the experiment suggest that the soil temperatures are the most crucial factor in summer production of coriander. The afternoon soil temperature if ameliorated and maintained between 28 °C to 32.5 ° C, coriander production can be taken up successfully without any modification of other weather factors like air temperature and relative humidity. However, amelioration in ambient air temperature further improves the efficiency of the production system.

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